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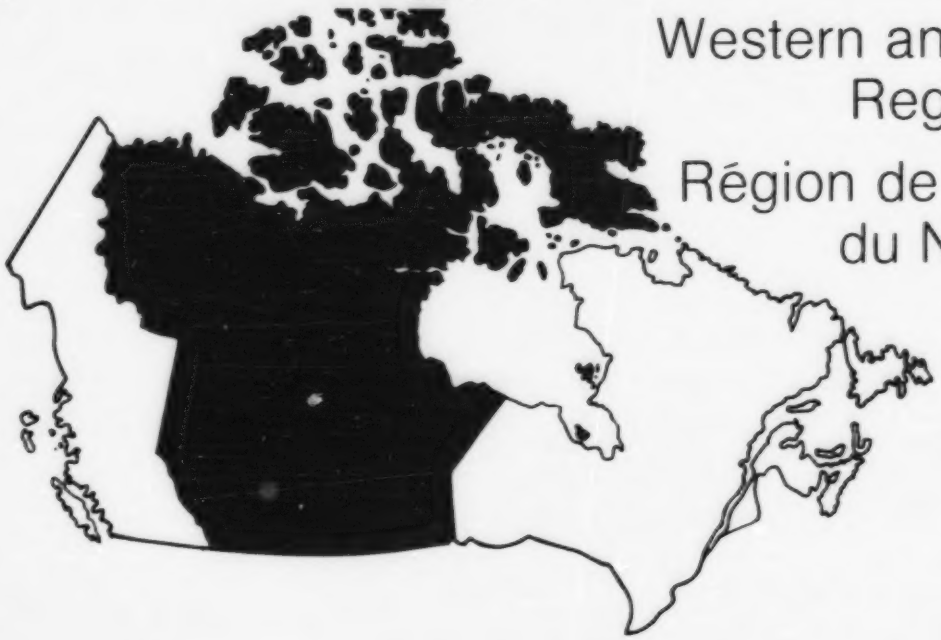

Western and Northern Region

Région de l'Ouest et du Nord

Environmental Protection

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AN ASSESSMENT OF EFFLUENT QUALITY AT A LARGE METAL FINISHING PLANT

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and
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TABLE OF CONTENTS

	PAGE
TITLE PAGE	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
1.0 Introduction	1
2.0 Physical Description of Plant Plating Processes	2
3.0 Methods	4
3.1 Observation of Operating Procedures	4
3.2 Sampling of Rinse Tank Effluents and Plant Effluents	5
3.3 Wastewater Flow Measurements	6
4.0 Results	7
4.1 Description of the Plating Lines	7
4.1.1 Barrel Plating Line	7
4.1.2 Rack Plating Line	10
4.1.3 Specialty Plating Line	12
4.2 Existing Water Uses and Waste Management Practices	15
4.2.1 General Observations	15
4.2.2 Water Use	16
4.2.3 Current Waste Management Practices	17

TABLE OF CONTENTS (continued)

	PAGE
4.3 Waste Characterization	17
4.3.1 Water/Wastewater Flows	17
4.3.2 Wastewater Quality	18
5.0 Discussion	24
5.1 Regulatory Requirements	24
5.2 Code of Good Housekeeping Practice	27
5.3 Recommendations	28
5.3.1 Phase I	29
5.3.1.1 Barrel Plating Line	30
5.3.1.2 Rack Plating Line	33
5.3.1.3 Specialty Plating Line	38
5.3.1.4 General Recommendations	42
5.4 Impact of Waste Reduction Following Phase One Implementation	47
6.0 Summary and Conclusion	53
7.0 References	55

LIST OF TABLES

		PAGE
TABLE 1.	Barrel Plating Line Draining Times	9
TABLE 2.	Rack Plating Line Draining Times	12
TABLE 3.	Rinse Water Flow Rates on Barrel Plating Line	19
TABLE 4.	Rinse Water Flow Rates on Rack Plating Line	20
TABLE 5.	Wastewater Quality Data for Specialty Plating Line Effluent	21
TABLE 6.	Wastewater Quality Data for Combined Effluent from All Plating Lines	22
TABLE 7.	Comparison of the Federal Guideline Limits and Winnipeg Sewer Utility By-law Limits	25
TABLE 8.	Tap Water Impurities vs. Finishing Processes	37
TABLE 9.	Non-Cyanide Zinc Baths	42
TABLE 10.	Fresh Water Feed for Barrel Plating Line	48
TABLE 11.	Fresh Water Feed for Rack Plating Line	49
TABLE 12.	Theoretical Projections for Concentrations of Toxic Materials Assuming a 50 Percent Reduction in Water Use	52

LIST OF FIGURES

		PAGE
FIGURE 1.	Cadmium-Zinc-Tin Barrel Plating Line	8
FIGURE 2.	Cadmium-Zinc Rack Plating Line	11
FIGURE 3.	Specialty Plating Lines	13
FIGURE 4.	Changes to Barrel Plating Line - 1	31
FIGURE 5.	Changes to Barrel Plating Line - 2	32
FIGURE 6.	Recycle Rinse Water from Rack Plating to Barrel Plating Line	34
FIGURE 7.	Changes to Barrel Plating Line - 3	35
FIGURE 8.	Changes to Rack Plating Line - 1	36
FIGURE 9.	Changes to Rack Plating Line - 2	39
FIGURE 10.	Changes to Specialty Plating Line - 1	40
FIGURE 11.	Changes to Specialty Plating Line - 2	41
FIGURE 12.	Typical Drilling of Air Agitation Sparger	45

1.0 Introduction

Generators of small quantities of hazardous waste are often not aware of the availability of waste minimization technology. Furthermore, they often lack the capability to devise cost-effective waste management strategies.

A technical assistance program was developed in 1986 by Environmental Protection, Western and Northern Region of Environment Canada. It is directed at small industries, the first being metal finishing operations. Under this program companies may receive assistance through either a field assessment or audio-visual training courses.

The program focuses on "practical options" for reducing waste generation at source. It identifies and characterizes waste generation and provides recommendations for waste management alternatives to minimize waste generation at source through operational changes, process modifications, material substitution, waste exchange, and good housekeeping practices.

This report is a result of the effort of the technical assistance program aimed at assisting metal finishers to improve waste management at their plants. Special emphasis is placed on practical options for waste reduction at source.

2.0 Physical Description of Plant Plating Processes

The plant comprises three separate metal plating process lines: a Barrel Plating Line, a Rack Plating Line, and a Specialty Plating Line. The Barrel Plating Line consists of three metal plating processes: zinc, cadmium and tin. Generally the items processed on this line are small, such as nuts and bolts, which are not harmed by the abrasion resulting from continuing agitation in the plating solutions. Rack Plating involves large tanks in which racks holding small to large items can be immersed. Both zinc and cadmium plating are also conducted on this line. The Specialty Plating Line is used for a variety of metal plating operations for which small numbers of pieces are typically treated more or less individually. Plating operations undertaken on the Specialty Plating Line include aluminum, cadmium, copper, nickel, tin, silver. The plating that takes place on this line must meet critical quality standards.

The water supply for rinsing is obtained from the City of Winnipeg supply system and an on-site well. There are no rinsing stations with more than two rinse tanks. Spent rinse water from the Barrel Plating Line and the Rack Plating Line is discharged to a drainage flume in the floor of the plant and drains to a wet well for all plant effluents. Spent rinse water from the Specialty Plating Line drains through a

series of pipes to the plant wet well. The combined effluents in the plant wet well then drain to the Winnipeg sewer system.

3.0 Methods

3.1 Observations of Operating Procedures

Environment Canada initially obtained a general description of plant plating lines and processes by interviewing plant supervisors and management. This information was used to determine sampling and analytical requirements. On-site sampling and data collection were conducted during the weeks of December 1 and 15, 1986. There were three plating lines and it required three days to gather information and collect samples. Composite samples from the Specialty Plating Line and the final plant effluent were also collected for an additional week.

When data for each plating line were collected the procedure followed was to first ask the plating line supervisor and operator to describe the plating operations on the line and the contents of each tank. This information was used to prepare process diagrams. Tank dimensions and rinse tank temperatures were also recorded. During the period of data collection the operator was observed to determine the sequence of tanks used and to record some drag-out times.

The rinse tanks were observed to see if counter-current rinsing was practiced, and the source of the rinse water was also identified -- well water or City of Winnipeg water. The

condition of all tanks and pipes on each plating line was observed to identify leakage, but none was found.

3.2 Sampling of Rinse Tank Effluents and Plant Effluents

Grab samples of effluents from rinse tanks on the Barrel Plating Line and the Rack Plating Line were each collected on one occasion. These samples were collected during the week of December 1, 1986.

Composite samples of plating line effluents were collected at two locations in the plant; one from a sampling port on the single main discharge pipe for the Specialty Plating Line, and the second from a final effluent wet well receiving the combined effluents from all plating lines in the plant. These composite samples were collected on December 3, 4, 15, 16, 17, 18 and 19, 1986, between 08:00 and 16:00 hrs. during plating operations, using 20 minute sampling intervals.

All samples were refrigerated and shipped to the Environmental Protection Regional Laboratory in Edmonton. No sample preservatives were used. The sampling directives in the federal Metal Finishing Liquid Effluent Guidelines (1) were followed.

The parameters determined for rinse water effluents were: pH, conductivity, temperature, aluminum, cadmium, chromium, copper, cyanide, iron, nickel, silver and zinc. All parameters were analyzed for the composite samples, but not necessarily for individual rinses.

Temperature and pH measurements were made in the field. The pH meter used was a Metrohm Unit, model number E588. The other analyses were conducted by the Environmental Protection Regional Laboratory in Edmonton. All analyses followed the procedures outlined in the "Standard Methods" manual (2).

3.3 Wastewater Flow Measurements

Wastewater flows from each rinse tank discharging from the Barrel Plating Line and the Rack Plating Line were determined directly by using a stop watch and a calibrated container. The cadmium rinses on both lines were not flowing during the data collection period.

When measuring each flow rate at least three individual determinations were made at each rinse. The mean values were reported as the actual flow.

It was not possible to measure flows on the Specialty Plating Line because the spent rinse water was collected through a closed system of pipes.

4.0 Results

4.1 Description of the Plating Line

4.1.1 Barrel Plating Line

The Barrel Plating Line consists of cleaning, plating, and rinse tanks of uniform size as illustrated in Figure 1.

The standard barrel plating operation involves placing metal pieces in a plastic barrel, which is perforated with many holes to permit the circulation of liquid, and then immersing this container in the appropriate process and rinse tanks. The tanks are each equipped with apparatus to rotate the barrels while they are immersed. It was noted that this apparatus was engaged in the cleaning, acid dip, plating and bright dip tanks, but was not normally used in the drag-out* and rinse tanks. The barrels are continuously rotated when engaged in the rotating gears.

When barrels are transferred from one tank to another, the operator permits a short period of draining time to

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* "Drag-out" typically refers to the process solution or rinse waters carried out from a tank when pieces are removed and transferred. A drag-out tank is a still rinse tank used immediately after a plating bath.

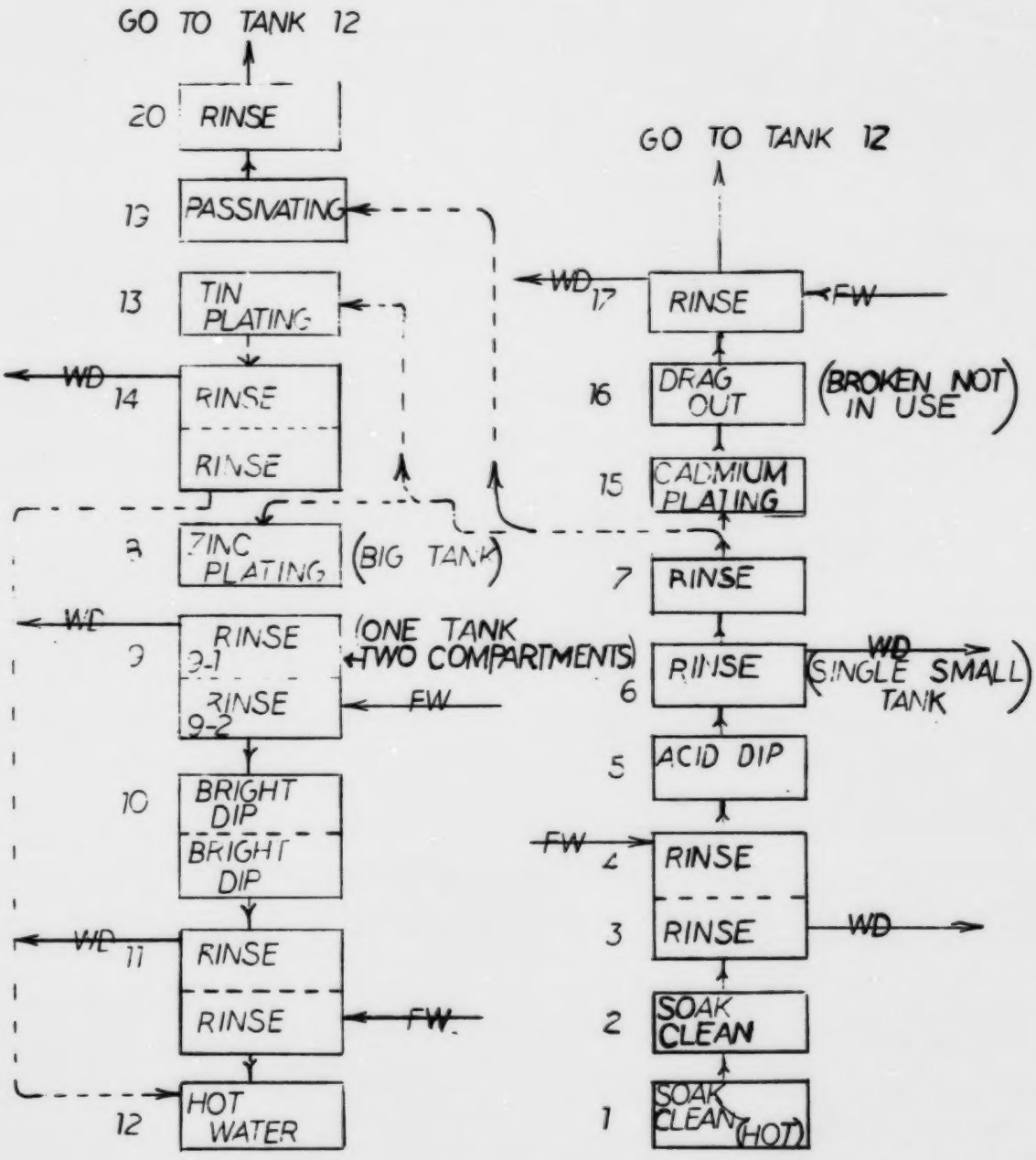

FIGURE 1. CADMIUM - ZINC - TIN BARREL PLATING LINE

Arrows marked with "FW" (fresh water) and "WD" (wastewater discharge) indicate the flow direction of rinse water. Other arrows indicate the direction of plating processes.

reduce drag-out before moving to the next tank. On one occasion, the drag-out period was timed; the results are reported in Table 1.

TRANSFER FROM	TO	DRAINING TIME
Cadmium plating bath	rinse tank	9 seconds
Zinc plating bath	rinse tank	7 seconds
Acid dip	rinse tank	13 seconds
Bright dip	rinse tank	5 seconds

Table 1. Barrel Plating Line Draining Times

These observations were recorded on one occasion (December 3, 1986) when samples were being collected.

The plating procedures on the Barrel Plating Line typically involve immersion in an alkaline soak clean bath, followed by rinsing, and then immersion in an acid dip bath followed by rinsing. The barrels are then transferred to the appropriate plating solution. After plating, the barrels are transferred to drag-out tanks and then to rinse tanks.

Sometimes the plating sequence includes a final bright dip and rinsing. A bright dip typically refers to a final treatment in an acidic solution to remove oxide from the metal surface thereby giving it a brighter appearance.

After final rinsing barrels are dipped in hot water and then emptied to permit the contents to dry.

4.1.2 Rack Plating Line

The Rack Plating Line (Figure 2) is located adjacent to the Barrel Plating Line. The Rack Plating Line tanks are located side by side in a single row. The fluid head maintained in these tanks is much higher than for the adjacent Barrel Plating Line and it is, therefore, possible to recycle rinse water to that line by gravity. There are no agitation or mixing devices in the rinse tanks.

The single operator of the Rack Plating Line follows specific sequences for particular products, but this varies from job to job. For example, the job may, or may not, call for yellow bright dip. The operator also must use considerable judgement in determining how long to immerse pieces in the process solutions and rinses. The operator also determines the amount of time to permit for drag-out. On one occasion the drag-out period following several rinses was measured to determine length and uniformity. These data are given in Table 2.

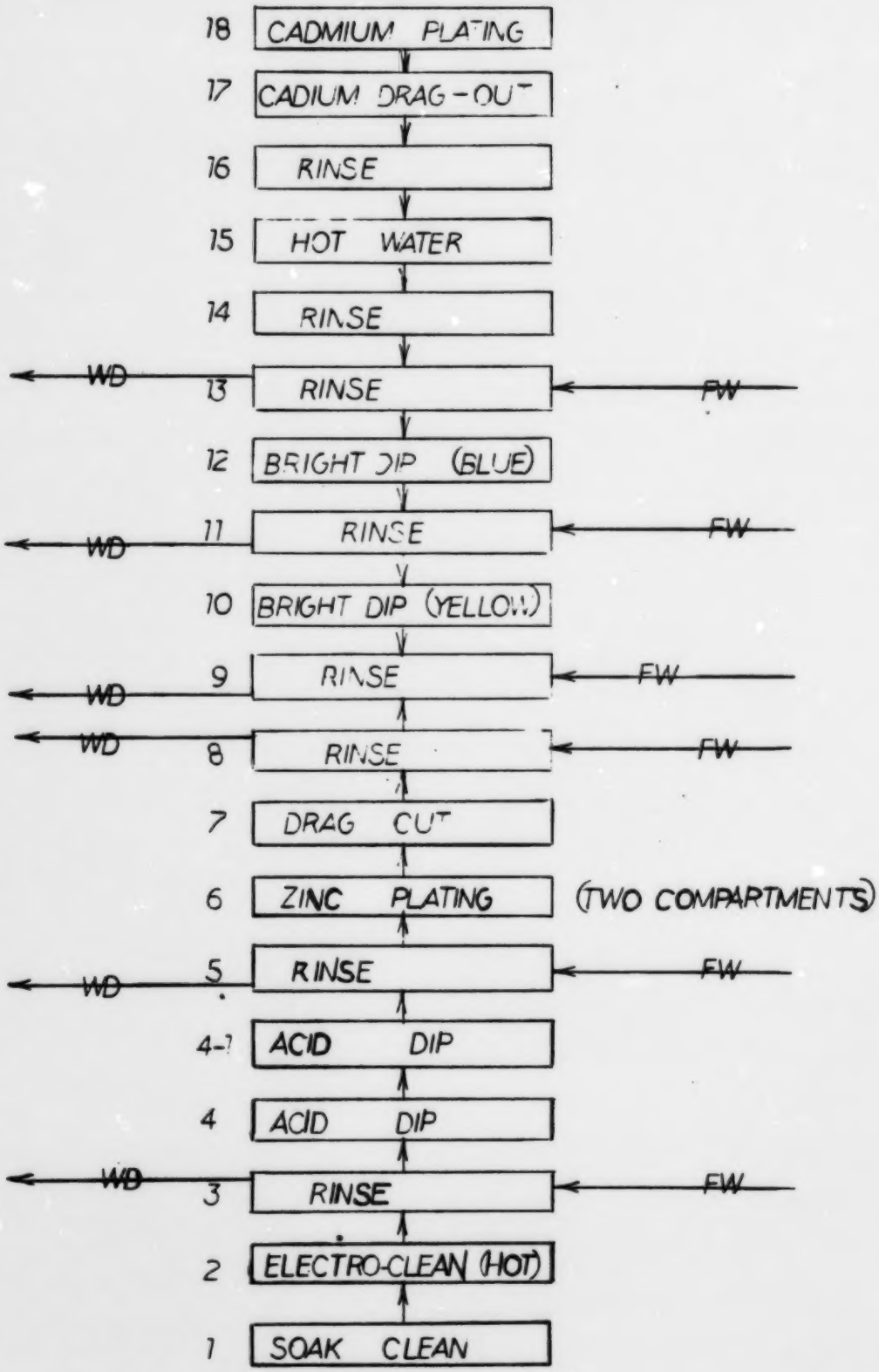

FIGURE 2. **CADMIUM - ZINC RACK PLATING LINE**

Arrows marked with "FW" (fresh water) and "WD" (wastewater discharge) indicate the flow direction of rinse water.

TRANSFER FROM	TO	DRAINING TIME
Cadmium plating bath	Cadmium drag-out	4 seconds
Cadmium plating bath	Cadmium drag-out	9 seconds
Cadmium plating bath	Cadmium drag-out	14 seconds
Bright dip	Rinse tank	2 seconds

Table 2. Rack Plating Line Draining Times

These periods were observed on one occasion (December 3, 1986) when samples were being collected.

4.1.3 Specialty Plating Line

The Specialty Plating Line (Figure 3) consists of many smaller cleaning, treatment and rinse tanks located in a separate area of the plant from the other plating lines.

Several different plating operations can be conducted on the Specialty Plating Line and these include: aluminum, cadmium, copper, nickel, silver, and tin plating. Several operators work in this area of the plant and the various treatment processes may be ongoing simultaneously.

Usually only a small number of pieces undergo plating on the specialty line at a time. They are typically suspended by a wire which is placed, by hand, on a rack at the top of a tank, and removed in the same manner. Operators follow

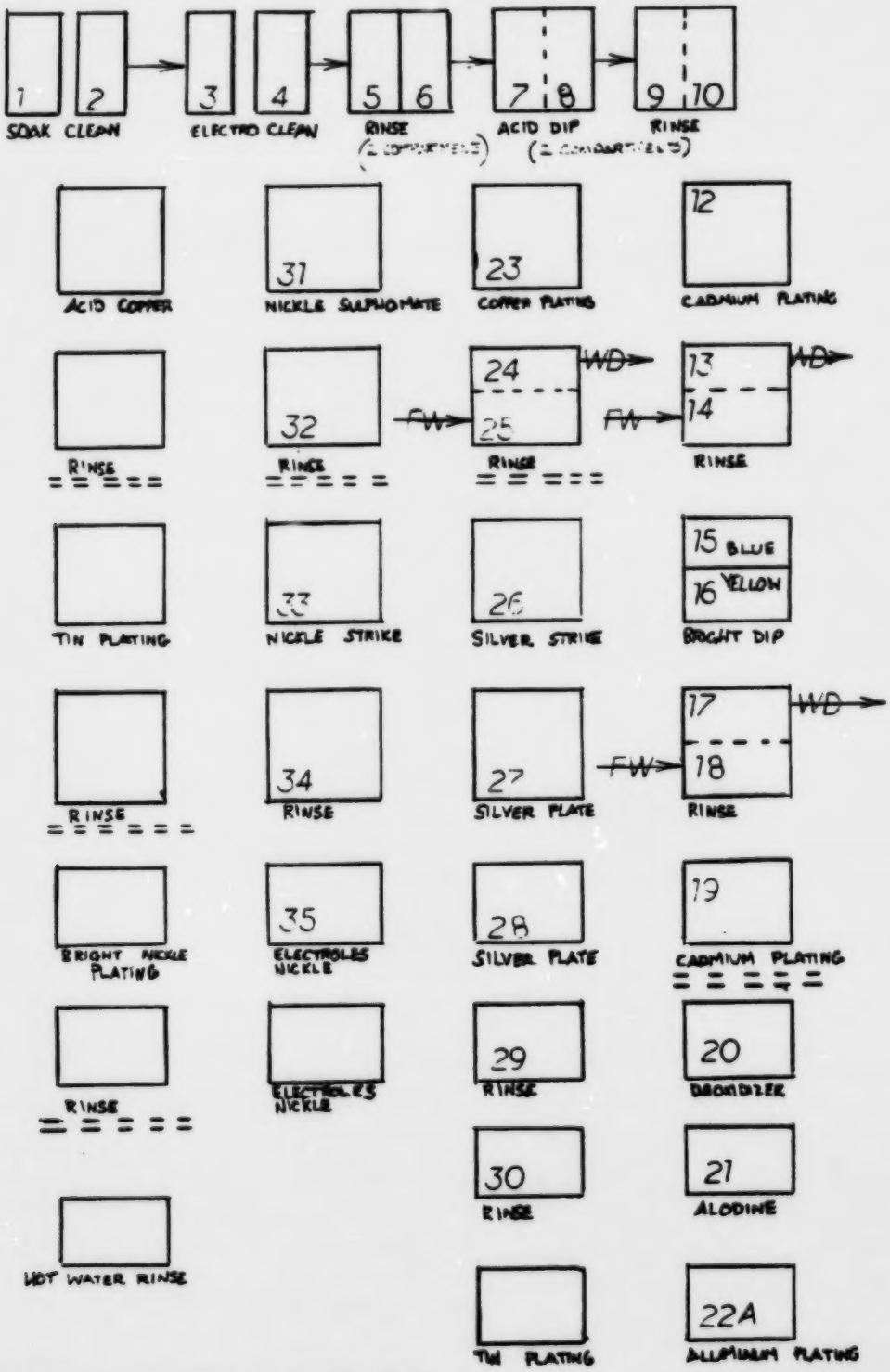

FIGURE 3. SPECIALTY PLATING LINES

Information concerning some of the plating lines. Arrows marked with "FW" (fresh water) and "WD" (wastewater discharge) indicate the flow direction of rinse water.

established process sequences and periods for various operations involved in plating, however, the operators control the actual dip times in each tank -- surface preparation, plating and rinsing.

The times permitted for draining and rinsing are not designated in the process operations; they are essentially determined at the operator's discretion. During draining the operator holds the pieces over the tank.

The pre-plating treatment for most processes is similar. Pieces are initially placed in a soak-clean solution and rinsed; they are then immersed in an electroclean rinse with an impressed current and rinsed again (Figure 3). This is usually followed by an acid dip treatment (muriatic acid) from which pieces may be transferred to one or more plating processes. The details of all plating processes on the Specialty Plating Line are not reported. An example of a plating procedure conducted on the line is the treatment of aluminum surfaces for coating.

The Specialty Plating Line includes facilities for the pretreatment of aluminum pieces for painting or plating. Following the initial surface preparation aluminum pieces are transferred to a "deoxidizer" solution containing nitric acid for the removal of scale. This process is also referred to as "acid etching". If aluminum surfaces are to be prepared

for painting, they are pretreated in a "chromium-free conversion coating" solution using a proprietary bath, Alodine, followed by a water rinse. If aluminum surfaces are to be prepared for plating, they are placed in a "zincate" solution consisting of zinc oxide in caustic which improves the binding properties for other metals. Following rinsing, the pieces are transferred to an appropriate metal plating solution, for example, electroless nickel plating.

4.2 Existing Water Uses and Waste Management Practices

4.2.1 General Observations

Steel tanks were used on all plating lines. Most tanks had an outer coating of protective material. The only tank leakage observed was a small amount from a seam on Tank 5 (acid dip) on the Rack Plating Line. The plumbing for most tanks on the three lines was generally subject to corrosion, but no serious leaks were observed.

There were no drain boards between tanks. There was limited protection from overflows when adding fresh water to process tanks to compensate for evaporative and drag-out losses. It is possible that some chemical spillages could occur when reagents are added to process solutions or when new solutions are being prepared. There can be releases of plating chemicals during handling, especially if

supervision and dispensing procedures are inadequate. There was no storage room for chemicals.

4.2.2 Water Use

Ground water from the on-site well is used for most rinsing on the Barrel Plating Line and the Rack Plating Line. The cadmium plating rinses on these lines take water from The City of Winnipeg water supply. City water is used for all rinses on the Specialty Plating Line.

There is an abundant supply of ground water and during the operating day water to all rinse tanks on the Barrel Plating Line and Rack Plating Line, with the exception of the cadmium rinse tanks, is turned on at the commencement of operation in the morning and run continuously during the day, including flows to some rinse tanks not in use. City of Winnipeg water for the cadmium rinse tanks on the two lines is turned on only during cadmium plating operations. City water is also used as make-up for treatment baths, and the final hot water baths on each line.

For most rinsing stations two rinse tanks are used and countercurrent rinsing is practiced. (Figures 1, 2, 3). Fresh water is introduced into the second tank at the free board. Rinse water is then discharged through an overflow weir, and conducted to the bottom of the first rinse tank

from which it passes an overflow weir into a discharge pipe. There are no flow restriction valves for any of the rinse tanks. There are no air agitation devices to promote or enhance rinsing. There is no recycling of water.

4.2.3 Current Waste Management Practices

There is no treatment of discharged rinse water before disposal. Spent process baths are also discharged to the sewers without treatment, although the pH is monitored before disposal. The plant does not have any equipment to reclaim heavy metals, destroy cyanide or otherwise remove toxics from wastewater. There are no records of disposal frequencies of spent plating and treatment baths. Sludges have been disposed of at City of Winnipeg landfills.

4.3 Waste Characterization

4.3.1 Water/Wastewater Flows

There is no metering equipment to measure water flows in the plant, however company representatives have estimated that the total utilization for plating is 75 Imperial gallons (338 litres) per minute. The results of

flow measurements determined for the Barrel Plating Line and the Rack Plating Line are recorded in Tables 3 and 4 respectively. During an eight-hour work period (December 3, 1986) approximately 36,960 litres (8,130 IG) of wastewater was generated on the Barrel Plating Line. Wastewater from the rinsing operations on the Rack Plating Line for the same period (December 3, 1986) was estimated to be 70,500 litres (15,510 IG).

Flow rates to the various rinsing operations on the Specialty Plating Line were not measured. However, based upon a total water utilization rate of 75 IGPM, estimated by the Company for the three plating lines, the wastewater flow from the Specialty Plating Line could be approximated at 58,000 litres (13,000 IG) for an eight hour operating period.

4.3.2. Wastewater Quality

The composite sampling data reported for seven sampling occasions during December 1986, are presented in Tables 5 and 6. The pH of the Specialty Plating Line effluent tends to be neutral to slightly alkaline, and the conductivity tends to be low (Table 5). The combined effluent from all plating lines (Table 6) tend to be moderately alkaline, and have relatively high conductivity values.

Rinse Tank and Number	Flow Rate L/Min	Flow: L Per Day (8.0 hr)
Soak Clean Rinse Tanks 3 and 4	16.6	8,000
Acid Dip Rinse Tanks 6 and 7	26.5	12,704
Zinc Plating Rinse Tanks 9.1 and 9.2	5.1	2,448
Bright Dip Rinse Tanks 11.1 and 11.2	11.0	5,296
Tin Plating Rinse Tank 14.1 and 14.2	17.7	8,512
Total Daily Flow	**77.0**	**36,960**

(Flow Rate: 8,130 IGPD)

Table 3. Rinse Water Flow Rates on Barrel Plating Line

Rinse water was flowing continuously during the day to all rinse tanks, with the exception of the cadmium rinse, when these rates were determined on December 3, 1986.

Rinse Tank and Number	Flow Rate L/Min	Daily Rate of Flow L/Day (8 hr)
Electro-Clean Rinse Tanks 3 and 4	21.9	10,195
Acid Dip Rinse Tank 5	39.0	18,704
Zinc Plating Rinse One Tank 8	20.0	9,552
Zinc Plating Rinse Two Tank 9	22.5	10,784
Yellow Bright Dip Rinse Tank 11	23.3	11,200
Blue Bright Dip Rinse Tank 13	21.0	10,064
Cadmium Rinse Tank 16 (City of Wpg. Water)	Not in Use	Not in Use
Total Daily Flow	**77.0**	**36,960**

(Flow Rate: 15,508 IGPD)

Table 4. Rinse Water Flow Rates on Rack Plating Line

Rinse water was flowing continuously during the day to all rinse tanks, with the exception of the cadmium rinse, when these rates were determined on December 3, 1986.

DATE 1986	PH	Conductivity umho/cm	CN mg/L	Al mg/L	Ag mg/L	Cd mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Ni mg/L	Zn Mg/L
Dec 4	-	188	0.98	0.3	<0.03	0.39	0.31	0.27	0.16	0.55	.037
Dec 5	-	189	0.63	0.01	<0.03	0.21	0.11	0.35	0.19	0.74	.024
Dec 15	7.2	227	1,89	0.3	<0.03	0.77	0.68	0.15	0.24	0.83	.433
Dec 16	7.5	227	2.36	0.3	<0.06	1.02	0.57	0.45	0.25	1.73	.758
Dec 17	7.0	222	0.19	0.2	<0.03	0.46	0.33	0.28	0.17	0.94	.273
Dec 18	7.2	215	0.84	0.1	<0.03	0.36	0.17	0.24	0.21	0.81	.974
Dec 19	7.2	209	0.96	0.2	<0.03	0.44	0.19	0.20	0.29	0.38	.067
Average		211	1.12	0.20	<0.03	0.52	0.34	0.28	0.22	0.85	.37

Table 5. Wastewater Quality Data For Specialty Plating Line Effluent

This data was obtained from composite samples of effluent taken from the main discharge pipe for the Specialty Plating line.

DATE 1986	PH	Conductivity umho/cm	CN mg/L	Al Mg/L	Ag Mg/L	Cd Mg/L	Cr Mg/L	Cu Mg/L	Fe Mg/L	Ni Mg/L	Zn Mg/L
Dec 3	7.0	1746	7.56	<0.1	<0.03	0.40	0.14	0.35	2.66	0.288	8.19
Dec 4	7.4	1719	7.26	0.1	<0.03	0.95	0.21	0.42	2.30	0.23	5.92
Dec 15	8.1	1712	15.3	0.1	<0.03	1.37	1.04	0.66	2.35	0.34	10.7
Dec 16	8.3	1597	15.7	0.1	<0.03	2.17	0.45	0.65	3.38	0.85	9.71
Dec 17	7.6	1597	10.8	0.2	<0.03	0.61	0.35	1.41	2.01	0.38	7.64
Dec 18	7.3	1539	4.27	<0.01	<0.08	0.30	0.22	1.01	1.38	0.32	3.82
Dec 19	7.7	1597	5.09	<0.1	<0.03	0.28	0.15	0.89	1.93	0.17	4.86
Average		1644	9.42	0.1	<0.03	0.87	0.37	0.77	2.29	0.37	7.26

Table 6. Wastewater Quality Data for Combined Effluent from All Plating Lines

This data was obtained from composite samples of effluent collected during operation from the wet well receiving effluent from the three plating lines.

During the collection period, there were considerable fluctuations in most of the parameters monitored in the composite samples. These variations reflected rinsing activities.

5.0 Discussion

5.1 Regulatory Requirements

In Manitoba there has been virtually no regulation of the metal finishing industry. During 1988 The City of Winnipeg established limits for several metals in its Sewer Utility By-law. These limits and the federal guideline limits for metals and other substances are listed in Table 7. The City of Winnipeg limits could be applied to all industries which discharge to the sewer system. As a result of the new Manitoba Environment Act some responsibility for regulating the metal finishing industry could be shifted to the provincial government.

The City of Winnipeg no longer permits the disposal of sludge from metal finishing plants at its waste disposal sites. There are no data available on the sludge disposal practices followed by metal finishers in Winnipeg. In 1988 the Manitoba Dangerous Goods Handling and Transportation Act required each generator of hazardous waste in the Province to obtain a licence; this includes metal finishers. Carriers of hazardous wastes also require licences. Manitoba intends to work with industrial waste generators to identify their specific needs and have these addressed by the Manitoba Hazardous Waste Management Corporation.

Substance	Federal Guideline Limit mg/L	Winnipeg Sewer Utility By-law Limits mg/L
1. Aluminum	No Limit	50.0
2. Cadmium	1.5	2.0
3. Chromium (Total)	1.0	15.0
4. Chromium (Hexavalent)	Not Applicable	5.0
5. Copper	1.0	5.0
6. Lead	1.5	2.0
7. Mercury	No Limit	0.1
8. Nickel	2.0	5.0
9. Zinc	2.0	5.0
10. Cyanide (Oxidizable)	0.1	2.0
11. Cyanide (Total)	3.0	10.0
12. Total Suspended Matter	30.0	No Limit

Table 7: Comparison of Federal Guideline Limits and Winnipeg Sewer Utility By-law Limits

Comparison of limits for substances discharged in the federal "Metal Finishing Liquid Effluent Guidelines" and the City of Winnipeg Sewer Utility By-law. The pH range in the Guideline is 6.0 to 9.5; in the By-law the range is 5.5 to 9.0.

During 1982 and 1983 Environment Canada conducted an inventory of metal finishing operations in Manitoba, which were described as "medium sized to very small". At that time all known plants discharged untreated effluents to municipal sewer systems.

The Government of Canada issued "Metal Finishing Liquid Effluent Guidelines" (1) in 1977 under the authority of the Minister of Fisheries and the Environment. The substances and parameters considered for the purposes of the Guidelines include:

(a)	Total suspended matter	(f)	Cyanide (Total)
(b)	Cadmium	(g)	Lead
(c)	Chromium (Total)	(h)	Nickel
(d)	Copper	(i)	Zinc
(e)	Cyanide (Oxidizable)	(j)	pH

The federal guidelines are national baseline standards which are considered achievable through the implementation of "best practicable technology" (that is, technology which is both technically and economically viable). While a guideline is not enforceable it does indicate what practices are considered acceptable with respect to the intent of a particular Act of Parliament; in this case, with respect to the Fisheries Act.

The federal guidelines provide objective concentrations for various substances and for pH in the final effluent from metal finishing plants; they provide a format for reporting

concentrations of substances in effluent; and they provide reporting formats when disposing of spent processing solutions, sludges and residues.

5.2 Code of Good Housekeeping Practice

The federal guidelines manual (1) includes a "Code of Good Housekeeping Practice for the Metal Finishing Industry". It is described as supplemental to the guidelines and "was prepared to indicate methods and practices which should be followed to assist in meeting the requirements of the guidelines". The Code states, "conscientious supervision is the most important single factor in effecting good housekeeping practices".

Substitutes can be obtained for various toxic chemicals used in metal finishing.

The Code (1) identifies several ways applicable to this study in which plant operators may reduce the release of contaminants:

1. "Cleaners containing non-biodegradable compounds should be completely avoided.
2. "The use of phosphates should be eliminated, if possible, or at least reduced to the lowest possible concentration.
3. "An effort should be made to replace environmentally dangerous chemicals with those less toxic or more readily removed from the effluent stream.

4. Wherever possible baths should be operated at the lowest concentration practicable."

The Code (1) states that plant operators are in the best position to determine rinsing needs and this can be done empirically by metal finishers themselves. Once a sufficient flow is established for a specific rinse tank, flow restrictors can be installed. None of the plating lines at the plant which was the subject of this study had any devices to enhance rinsing efficiency. The Code outlines several things which could be considered for each plating line:

1. Agitation of work while in the rinse tank;
2. Air agitation of the rinse water;
3. Hydraulic agitation of the rinse water;
4. Mechanical agitation of the rinse water with mixers or impellers;
5. Ultrasonic agitation of the rinse water;
6. Raising the water temperature;
7. Use of wetting agents; and
8. Introduction of fresh water at the bottom of the rinse tanks, using a spreader wherever possible.

5.3 Recommendations

Based on the foregoing information and assessments we make the following recommendations for operational and process changes. These recommendations deal with optimization of water use, and a reduction in the generation of toxic waste through efficient use and containment of cleaning and process chemicals. We recommend a two-phase strategy for improvement of waste management. This study constitutes Phase I in reducing the release into the

environment of toxic materials associated with metal finishing. Phase II would involve end-of-pipe treatment of effluents from waste streams to recycle or remove toxic materials before discharge from the plant. Phase II should be regarded as a last resort after every attempt has been made to reduce waste generation. Phase I provides the best measure to minimize the cost of end-of-pipe treatment and the associated expense of hazardous waste disposal.

5.3.1 Phase I

The scope of Phase I includes action taken by the generator to modify plating processes or operational procedures to reduce the waste volume generated before the end-of-pipe treatment and disposal; and replacement of hazardous raw materials with less or non-hazardous ones to reduce the degree of hazards of wastes.

Rationales for some of the recommendations have been described immediately following the corresponding recommendations.

5.3.1.1 Barrel Plating Line

Recommendation 1

Recycle acid dip rinse water (Tank 6) back to soak clean rinse (Tank 4); shut off fresh water feed to Tank 4 (Figure 4).

This will offer the following advantages:

1) the pH of the combined rinse water will be neutralized.
2) The efficiency of the alkaline soak-clean rinse will be enhanced because of better removal of the soapy film on plating surfaces (3).
3) The service life of the acid dip solution will be increased.

Recommendation 2

Use hydrochloric acid rinse (Tank 6) to replace water evaporation in the hydrochloric acid dip tank (Tank 5) (Figure 4).

Because the evaporative loss from warm hydrochloric acid is little, only a small amount of acid rinse can be fed back. Even so, this would reduce the generation rate of waste water.

Recommendation 3

Convert the two compartments (rinses) of Tank 9, following the zinc plating bath, to a drag-out compartment and a single flowing rinse (Figures 1 and 5).

The drag-out compartment would reduce, as a rule of thumb, the zinc and cyanide concentrations in the running rinse by about 50%. Use the drag-out to compensate for evaporative losses from the zinc plating tank; in turn make up the drag-out tank with distilled or deionized water.

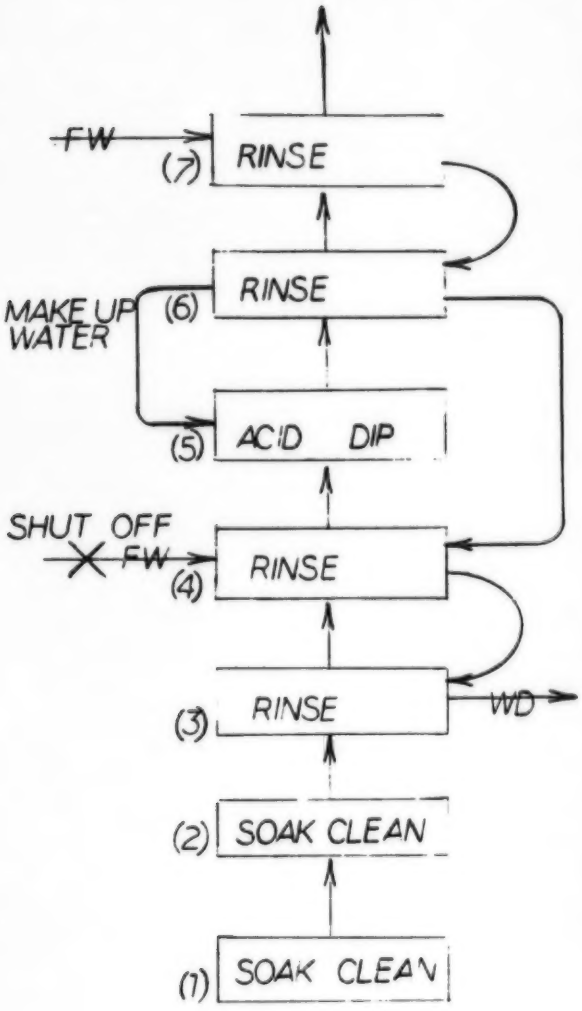

FIGURE 4. CHANGES TO BARREL PLATING LINE - 1

Rinse water from acid dip rinse recycled to soak clean rinse; acid dip rinse water may be used as make-up water for acid dip; shut off fresh water feed to soak clean rinse.
FW= fresh water, WD= wastewater discharge.

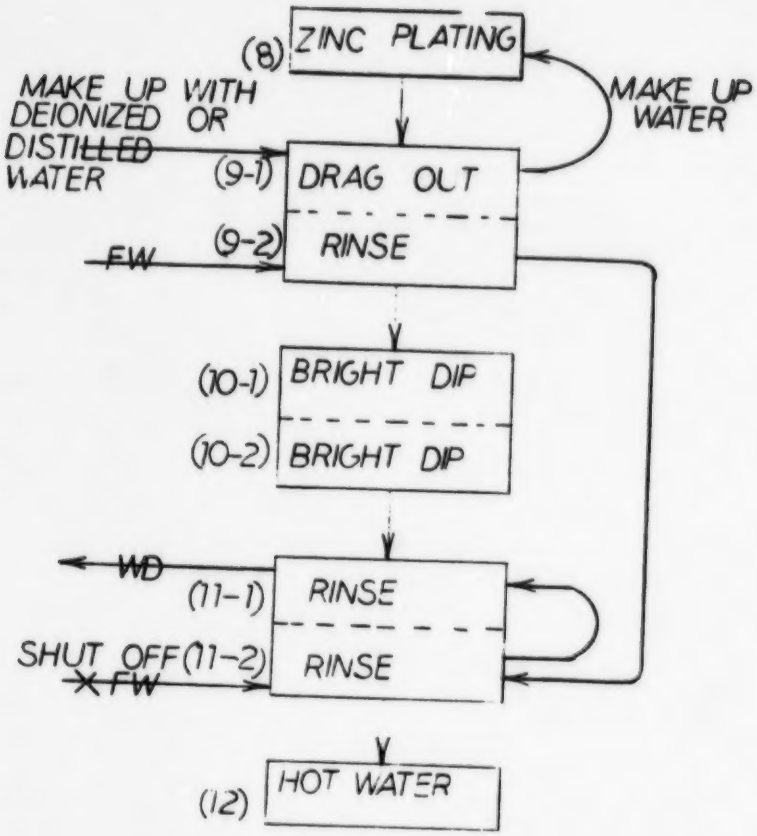

FIGURE 5. CHANGES TO BARREL PLATING LINE - 2

Rinse water tank 9-1 converted to zinc plating drag-out; zinc rinse recycled to bright dip rinse; drag-out used as make up water for zinc plating; shut off fresh water feed to bright dip rinse. FW= fresh water, WD= wastewater discharge.

Recommendation 4

Recycle zinc rinse water to bright dip rinse (Tank 11-2); turn off the fresh water feed to Tank 11-2 (Figure 5).

This would not harm the rinsing after the bright dip bath.

Recommendation 5

Recycle cadmium rinse water (Tank 16) of the Rack Line, by gravity feed, to the cadmium rinse water (Tank 17) of the barrel line; recycle Tank 17 of the barrel line to tin plating rinse (Tank 14); recycle rinse water from Tank 14 to Tank 20; shut off fresh water feed to Tanks 17, 14 and 20 (Figure 6 and 7).

Currently the plant uses city water instead of ground water for cadmium plating rinse in the rack line. One should not recycle tin rinse water in the barrel line to the cadmium rinse tank in the rack line because dissolved solids in ground water may cause imperfections on dried cadmium-plated surfaces.

5.3.1.2 Rack Plating Line

Recommendation 1

Recycle acid dip rinse water (Tank 5) to electroclean rinse (Tank 3); turn off fresh water feed to Tank 3 (Figure 8).

Recommendation 2

Convert the first zinc rinse (Tank 8), to a second drag-out tank; turn off the fresh water feed to Tank 8 (Figure 8).

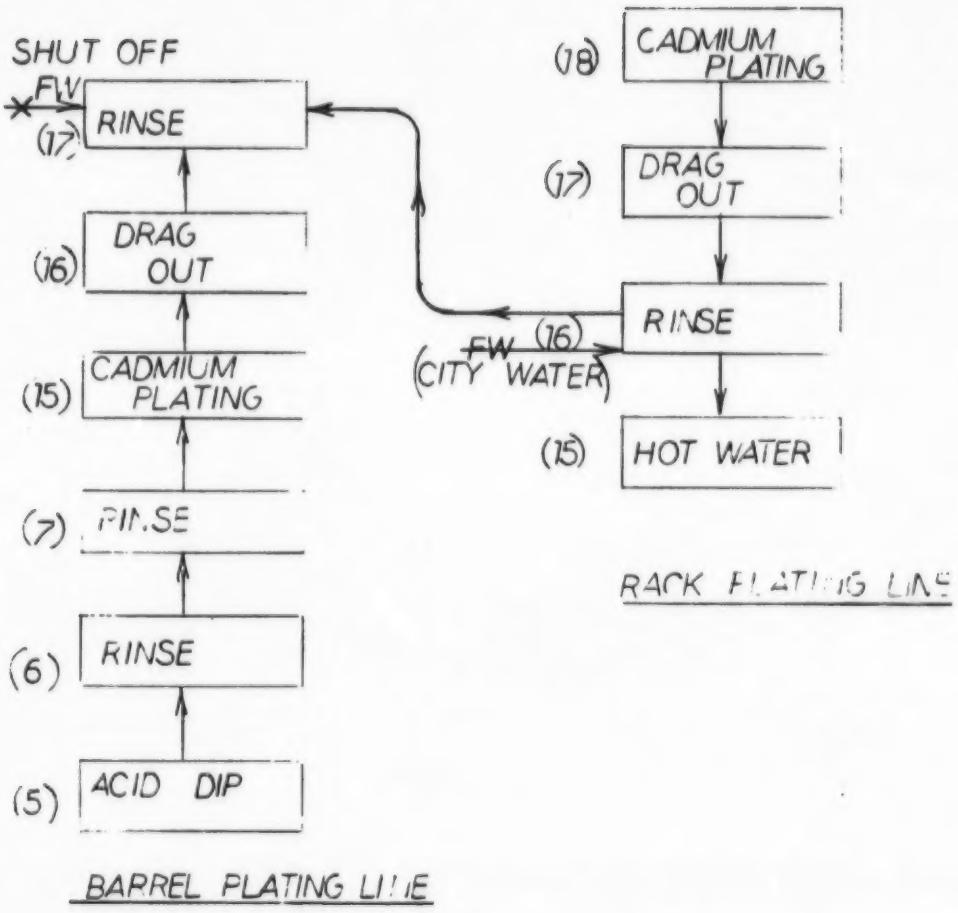

FIGURE 6. RECYCLE RINSE WATER FROM RACK PLATING LINE TO BARREL PLATING LINE

Cadmium rinse (city water) on rack plating line is recycled to cadmium rinse on barrel plating line; shut off fresh water feed to cadmium rinse on barrel plating line.
FW= fresh water, WD= wastewater discharge.

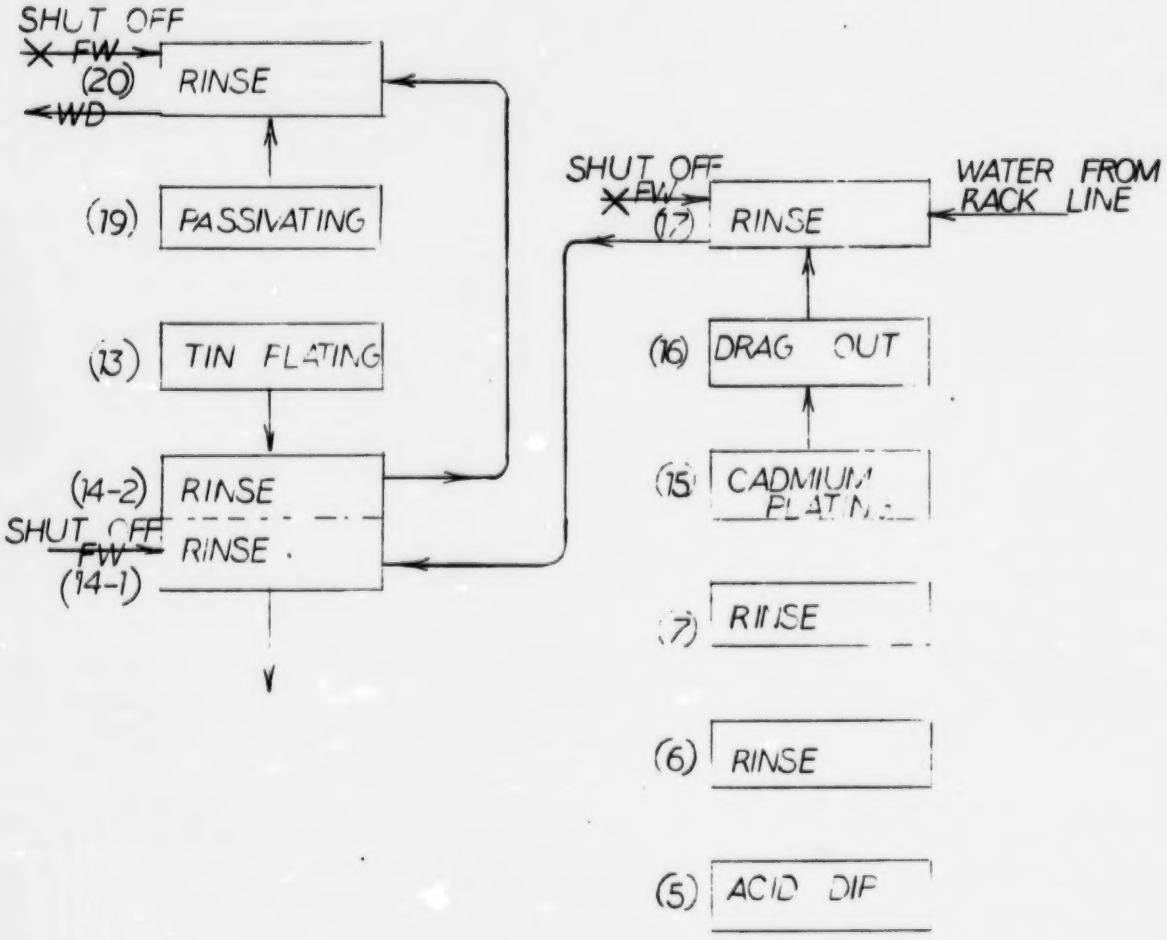

FIGURE 7. CHANGES TO BARREL PLATING LINE - 3

Cadmium rinse from rack plating line recycled to cadmium rinse on barrel plating line (Figure 6). Cadmium rinse on barrel plating line recycled to tin plating rinse; tin plating rinse recycled to passivating rinse; shut off fresh water feed to cadmium rinse, tin rinse, and passivating rinse. FW= fresh water, WD= wastewater discharge.

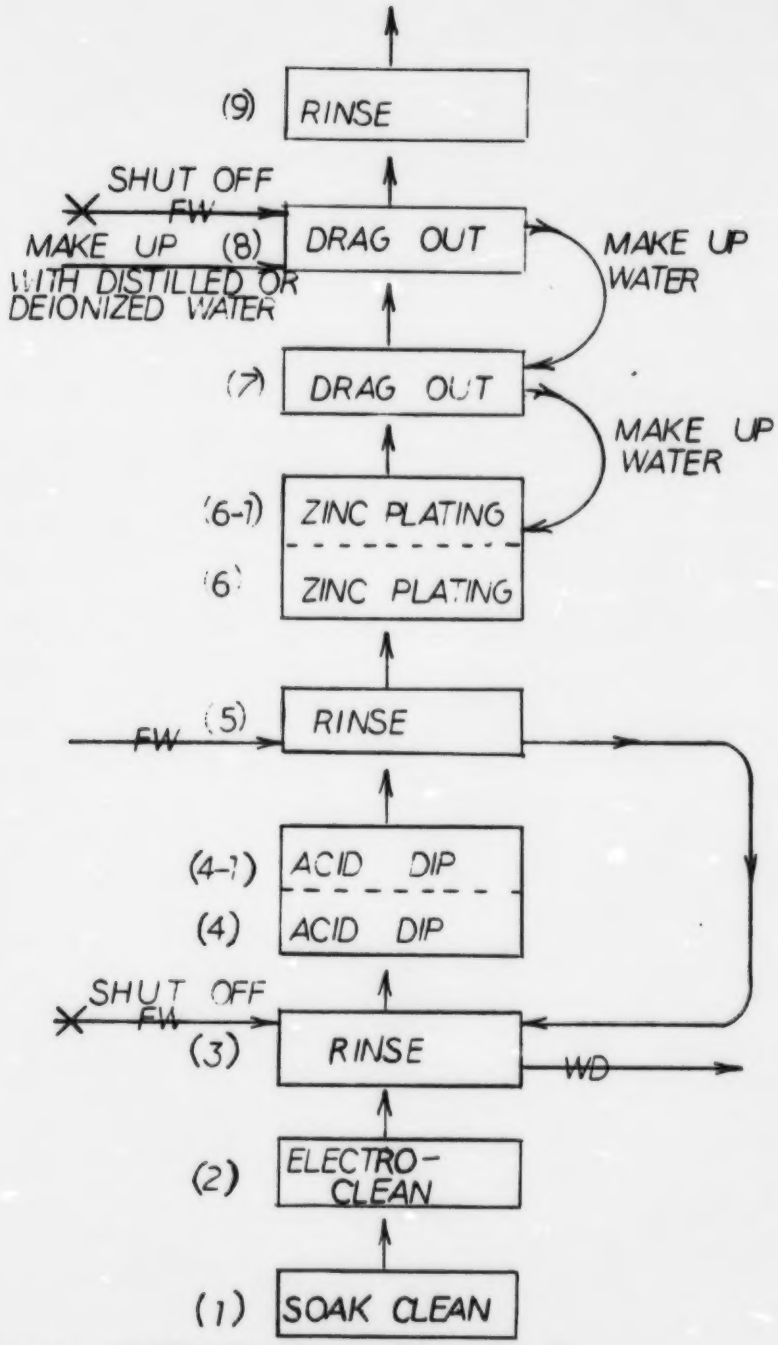

FIGURE 8. CHANGES TO RACK PLATING LINE - 1

First zinc rinse converted to a drag out; acid dip rinse recycled to electro clean rinse; shut off fresh water feed to tank 3 and tank 8; make up zinc plating solution with water from first zinc drag out; shut off fresh water feed to electro-clean rinse and former first zinc rinse.
FW= fresh water, WD= wastewater discharge.

Recommendation 3

Use the first zinc drag-out (Tank 7) as make-up liquid for plating bath evaporation (Tank 6) (Figure 8); do not add fresh tap water or ground water to the plating bath.

A large quantity of water will evaporate from the heated zinc plating bath (Tank 6). Returning the drag-out to the plating bath would not only recover valuable raw chemicals, but also minimize hazardous waste generation. It could provide an income rather than a payout for environmental control.

Recommendation 4

Recycle some of the liquid from the second drag-out tank (Tank 8) as make-up for the first (Tank 7); in turn make up the second with distilled or deionized water.

The quality of water used to prepare bath solutions is of great importance in plating processes. Some impurities in tap water may harm finishing processes (Table 8). Thus, if tap water or ground water is used to makeup evaporative losses, water impurities will become concentrated with time resulting in the need to more frequently dump bath solutions. The solution drained from the first dragout tank may be used to replace evaporative losses in the plating tank. For this reason only deionized or distilled water is used to fill the second dragout tank. Moreover, this helps minimize problems of imperfections on dried plated surfaces resulting from dissolved solids.

Ion	Finishing Process Affected
Chloride	Cr, Zn, Cu, Pb plating; Anodizing
Calcium	Anodizing
Copper	Cr, Ni, Ni-Fe plating
Iron	Cr, Ni, Ag Plating
Silica	Painting, General Cleaning
Sulfate	Cr, Pb Plating

Table 8. Tap Water Impurities vs Finishing Processes (Hankebo (4)

Recommendation 5

Reposition Tank 11 (Figure 2) between Tanks 9 and 10 (Figure 9); use counter flow for both Tanks 9 and 11 in series (Figure 9); shut off ground water feed to Tank 9.

Recommendation 6

Restore Tank 14 to service; use Tanks 13 and 14 in series for counterflow rinsing; shut off ground water feed to Tank 13 (Figure 9).

Currently Tank 14 is not in service. Using Tanks 13 and 14 in sequence for countercurrent rinsing would conserve water, thus reducing wastewater generation.

Recommendation 7

Recycle zinc plating rinse water (Tank 9) to Tank 14 (Figure 9).

This would not harm the rinsing for the bright dip (Tank 10 or 12).

5.3.1.3 Specialty Plating Line

Recommendation 1

Recycle the acid dip rinse water (Tank 9) to the electroclean rinse (Tank 6); shut off fresh water feed to Tank 6 (Figure 10).

Recommendation 2

Relocate Tank 19 (Figure 3) between Tank 12 and Tank 13 (Figure 11).

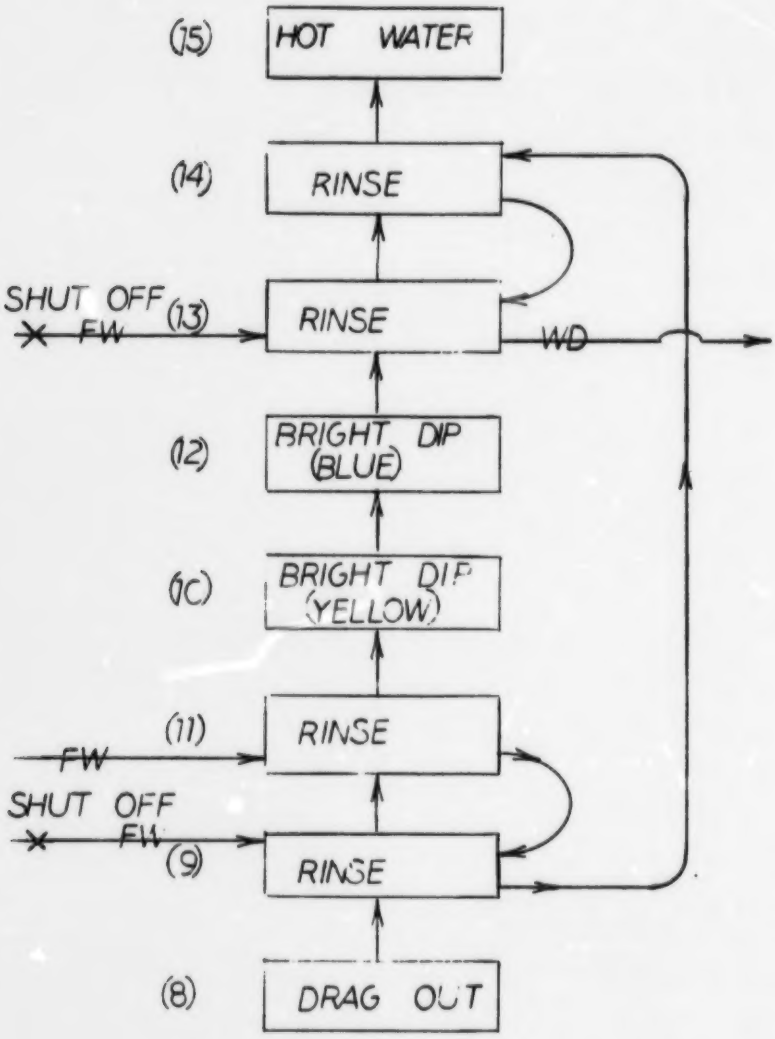

FIGURE 9. CHANGES TO RACK PLATING LINE - 2

Tank 11 relocated between tank 9 and 10; rinse water from tank 11 recycled to tank 9; rinse water from tank 9 recycled to tank 14 and then to tanks 13; tank 14 to be returned to service; shut off fresh water feed to tank 9 and 13.
FW= fresh water, WD= wastewater discharge.

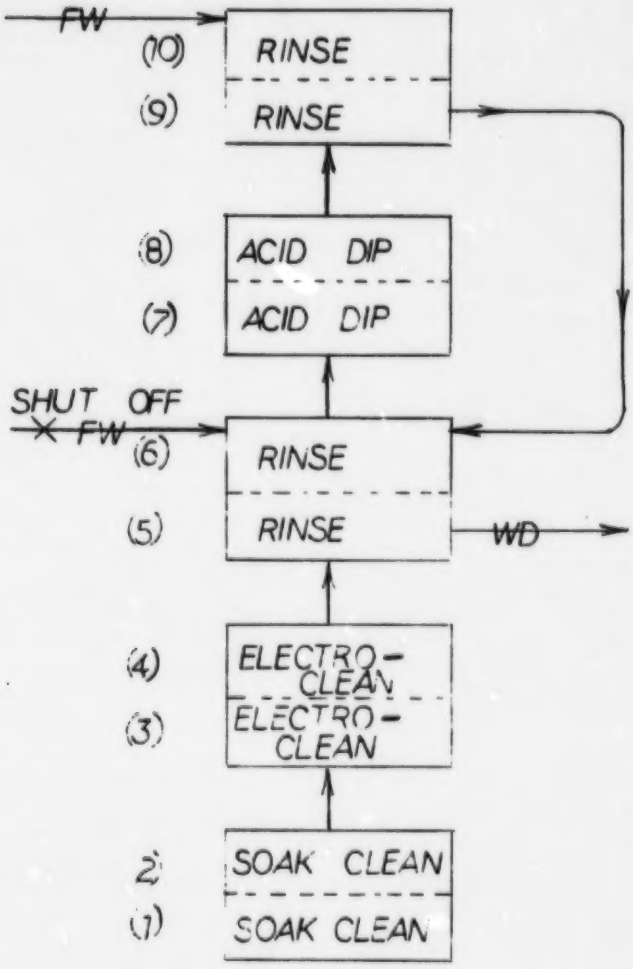

FIGURE 10. CHANGES TO SPECIALTY PLATING LINE - 1

Rinse water from acid dip rinse recycled to electro-clean rinse.

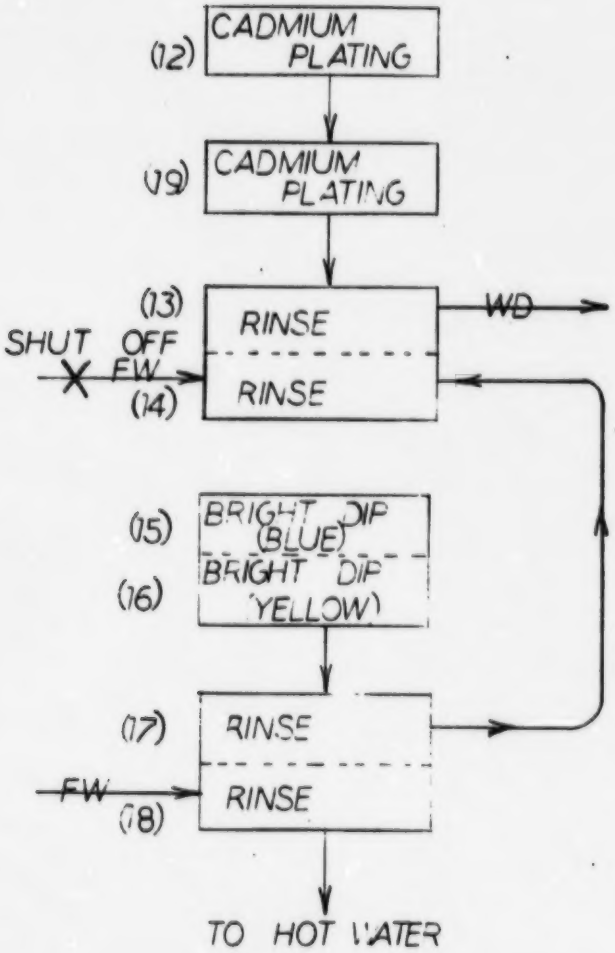

FIGURE 11. CHANGES TO SPECIALITY PLATING LINE - 2

Cadmium plating tank (tank 19) relocated; bright dip rinse recycled to cadmium rinse; shut off fresh water feed to bright dip rinse.
FW= fresh water, WD= wastewater discharge.

Recommendation 3

Recycle bright dip rinse water (Tank 17) to cadmium plating rinse (Tank 14); shut off fresh water feed to Tank 14 (Figure 11).

5.3.1.4 General Recommendations

The following recommendations may be applied to all plating lines.

Recommendation 1

Use cyanide-free cadmium and zinc baths instead of cyanide-containing baths.

Cadmium and zinc cyanide baths are costly and dangerous to operate and expensive to treat. The transport of spent solutions from electro-plating operations are regulated under the Transport of Dangerous Goods Act.

Cyanide-free baths for cadmium and zinc plating processes have been developed to replace cyanide baths. This type of material substitutions will eliminate the need of alkaline chlorination for the treatment of cyanide. Thus, using CYANIDE-FREE baths will result in a NET SAVING.

It has been the trend in the past decade to replace the cyanide zinc baths with non-cyanide zinc (Table 9). A recent survey by D'Angelo (5) shows that the latter now outnumbers the former by more than two to one.

Chloride Zinc Bath	Alkaline Zinc Bath
Zinc Chloride	Zinc Metal
Potassium Chloride	Sodium Hydroxide
Boric Acid	Sodium Carbonate
Ammonium Chloride	

Table 9. Non-Cyanide Zinc Baths
(D'Angelo (5))

Recommendation 2

Use a low temperature (50°C) alkaline cleaner instead of the higher temperature (70°C) one.

Low temperature alkaline cleaners offer the following advantages (Jansen and Tervoort (3):

1) They will reduce the heating energy cost between 40 and 50%, and
2) the cost of cleaner chemicals and the generation rate of wastewater will be reduced because of the prolongation of the cleaner life time.

Recommendation 3

Clean and remove the sediment from rinse tanks regularly.

Good housekeeping is a part of the answer for quality rinsing. It will also reduce the generation of wastewater.

Recommendation 4

Introduce fresh water into the bottom of rinse tanks through submerged perforated distribution pipes or diffusers to enhance rinsing efficiency.

This should result in a uniform flow of water through the rinse tank.

Recommendation 5

Install flow regulators on all rinse tanks with fresh water feed.

Flow regulators will inhibit operators from wasting water.

Recommendation 6

Use air agitation in all rinse tanks.

Agitation enhances rinsing efficiency as mentioned in section 5.2. Air agitation is a simple, inexpensive and effective method for inducing agitation in a rinse tank. The system consists of an air blower or

compressor, and an air distribution line. Air is introduced through a perforated pipe into the bottom of a tank. A PVC (1/2" or 1") pipe with one end capped can be used for distributing air (Figure 12) by drilling small holes on about 4" staggered centres. The hole size may be from 3/32" to 1/8". To ensure even distribution of air, the cross-sectional area of the pipe should be greater than the combined area of all holes (6).

It is recommended that an air filter be used in conjunction with an air supplier to prevent atmospheric dust from getting into the rinse tank. A blower is preferred over a compressor to supply air, because the latter may introduce oil vapors into the agitated tank. Moreover, a blower has advantages of low energy consumption and capital cost. Place the blower on a slotted platform well off the wet floor.

Recommendation 7

In addition to installing an air agitation system, the rinsing efficiency can be improved by lifting the barrel momentarily out of the rinse tank, allowing it to drain and then reimmersing it instead of leaving it immersed. This can be repeated.

Recommendation 8

Shut off fresh water feed to any plating process not in use during normal operating hours.

Currently the water feed to each rinse tank is controlled manually by an operator. The water feed is flowing when a plating line is not in use during working hours. It is suggested that a ball valve be installed in the main water supply pipe for each line and that it be used to shut off the fresh water supply to the entire line when not in operation.

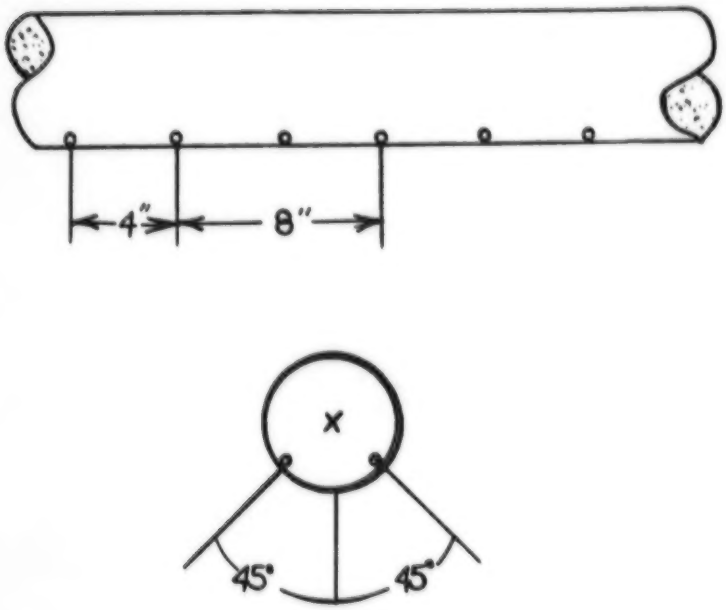

FIGURE 12. TYPICAL DRILLING OF AIR AGITATION SPARGER

From Mooney (6)

Recommendation 9

Minimize drag-out by holding work pieces over a plating tank for sufficient time to allow maximum drainage before transfer.

Care exercised by the operator is very important in reducing drag-out. To help reduce operator's fatigue, install a hoist delay time in the two manual hoist lines to provide a time delay needed for adequate draining, and install dwell hooks or slotted racks over tanks for drag-out control for the hand-line, i.e. the specialty line. The optimum draining time can be determined by experimentation.

Recommendation 10

Select the lowest possible metal concentration at which the plating bath can be operated.

The lower the concentration of a bath solution, the lower its viscosity. Lower viscosity will result in a reduction in drag-out volume. Thus, decreasing a bath concentration will not only reduce the drag-out volume, but also decrease the metal concentration of drag-out.

Recommendation 11

Maintain zinc and nickel baths at elevated temperatures during non-normal operating hours to induce additional water evaporation.

This technique involves no capital investment except some expenditure of energy. It provides room for recycling valuable chemicals from drag-out tanks back to plating baths.

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This technique involves no capital investment except some expenditure of energy. It provides room for recycling valuable chemicals from drag-out tanks back to plating baths.

Tank No.	Original Flow Rate GPM	Suggested Flow Rate GPM
4	4.38	0
6	6.88	5
9-2	1.33	1
11-1	2.91	0
17	3.42	0
14	4.69	0
20	3.57	0
TOTAL	27.18	6

Table 10. Fresh Water Feed for Barrel Plating Line

The flow reduction indicated is approximately 78 percent.

Tank No.	Original Flow Rate GPM	Suggested Flow Rate GPM
3	5.71	0
5	10.15	6
8	5.18	0 (converted to drag-out tank)
9	5.86	0
11	6.08	6
13	5.47	0
14	0 (Not in Use)	0
15	0*	3
TOTAL	**38.45**	**15**

Table 11. Fresh Water Feed for Rack Plating Line

The flow reduction indicated is approximately 61 percent.

*City of Winnipeg water used; fresh water feed was shut off during field visit.

There are no standards for limiting water use in the federal metal finishing guidelines or the City of Winnipeg Sewer Utility By-law. Simply regulating the concentrations of toxic materials in metal finishing effluents effectively encourages operators to meet concentration limits by diluting wastewater, especially when water is relatively inexpensive. This does not provide an incentive to reduce toxic materials entering wastewaters and sludges. Implementation of water and waste management practices may result, at least temporarily, in higher concentrations of toxic materials in wastewater. Some allowances for this may be necessary when process changes are being implemented. In such instances toxics concentrations in effluents may be higher but total loading should decrease. When process changes are complete, and waste concentrations in rinse water and drag-out tanks has been maximized then introduction of pollution control equipment, emphasizing recovery of metals and removal of toxics from plant effluents, can be implemented economically.

The benefits to the company of implementing a program include savings on raw materials resulting from minimization of drag-out, enhancement of rinsing efficiency, and a probable reduction of rejection rate of plated parts. The wastewater flow data reported indicates possible flow reductions of approximately 78 percent for the Barrel Plating Line, and 61 percent for the Rack

Plating Line. No flow data were collected for the Specialty Plating Line, however it is estimated that for the three plating lines a flow reduction of 50 percent is achievable.

A flow reduction of 50 percent, without concomitant reduction in the release of toxic materials, could theoretically result in a doubling of the concentrations of toxics in the final plant effluent. If the average concentrations of toxics reported in Table 6 were each doubled then most would still be within the limits established by the City of Winnipeg (Tables 7 and 12). Zinc is currently above the limit and could continue to increase as water conservation measures are introduced. Because of the release of zinc, at least during the sample collection period, it would be prudent to determine methods of conserving it during plating operations, and to implement measures for reclaiming and recovery.

Substance	Winnipeg Sewer By-law Limit mg/L	Average Concentration During Sample Collection Period mg/L	Average Concentration Following 50% Reduction in Water Use mg/L
Cadium	2.0	0.87	1.74
Chromium (Total)	15.0	0.37	0.74
Chromium (Hexavalent)	5.0	--	
Copper	5.0	0.77	1.54
Zinc	5.0	7.26	14.52
Nickel	5.0	0.37	0.74

Table 12. Theoretical Projections for Concentrations of Toxic Materials Assuming a Fifty Percent Reduction in Water Use

This table projects what the average effluent concentration of some toxic substances could be if a fifty percent reduction in water use was achieved without a concomitant reduction in the release of process materials. Zinc is the only substance, for which data was collected, that consistently exceeds the City of Winnipeg By-law limits for metals. The projections are based on data reported in Tables 6 and 7.

6.0 Summary and Conclusion

In Winnipeg, metal finishing plant wastewater effluent discharges may be regulated by the City of Winnipeg and the Province of Manitoba.

A two-phase strategy has been recommended to improve waste management at the plant. The present study outlines Phase I which deals with the volume and concentration of wastes associated with reuse of rinse water, air agitation, operational changes, material substitution and good housekeeping practices. Most recommendations could be implemented easily without the need of any sophisticated equipment. Preliminary data show that the waste volume may be reduced by as much as 70 percent on the Barrel Plating Line and 60 percent on the Rack Plating Line if Phase I recommendations are implemented. The projected concentrations of toxics in the final plant effluent are within the Winnipeg Sewer Utility By-law limits, except those for zinc.

Phase II involves end-of-pipe treatment and disposal, which could be implemented if regulatory pretreatment is required, but this is not within the scope of the present study.

It is suggested that a pollution reduction plan be developed by the company to control toxic materials in the wastewater effluents. This would include equipment requirements and an implementation schedule.

7.0 References

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7. Miller, S. and R. Cereck. "Blowers for Low-Pressure Air Supply", Plating and Surface Finishing, September, 1985, pp. 15-16.